AIR RESOURCE PROGRAM SUMMARY
ACADIA NATIONAL PARK, MAINE

(draft rev 10/99)

INTRODUCTION

Acadia National Park (ANP), Maine, is the only National Park in the northeastern United States. With more than 35,000 acres it is one of the largest publicly owned and protected natural areas in the region. Park owned lands are scattered across more than a dozen islands and a portion of the mainland on the Schoodic peninsula. In addition, the park has responsibility for administering approximately 160 conservation easements on more than ten thousand acres of privately owned lands within the Acadian archipelago. The park is characterized by a mix of northern coniferous and temperate deciduous forests, which meet and overlap at ANP, resulting in a rich and diverse flora of approximately 1200 species. More than 330 species of birds and 50 mammal species have also been recorded. Acadia NP has more than 52 miles of spectacular rocky shoreline with steep cliffs, sand and boulder beaches, and tidal pools containing abundant marine life.

Primarily as a result of long-range transport by prevailing winds, ANP periodically experiences high concentrations of a variety of air pollutants. Located along the mid-coast, the park is downwind from large urban and industrial areas in states to the south and west. The National Park Service (NPS) has established a comprehensive Air Resource Management program at ANP, a Class I area under the Clean Air Act (CAA), to better assess air pollution impacts and protect air quality related resources. The air resource program at ANP, which began in the early 1980's, includes monitoring, research, and regulatory interaction with state and federal agencies. Core program elements include long-term monitoring for ozone, sulfur dioxide, nitrogen oxides, volatile organic compounds (VOC's), fine particulates, visibility, mercury deposition acid precipitation, and ultraviolet radiation. In addition, there is an ongoing effort to determine the biological effects of selected air pollutants on park resources. Specific research studies include: deposition patterns and impacts of atmospheric contaminants on park watersheds (1998-2001); effects of ozone on native vegetation (1989-1997); pathological assessment of needle injury on eastern white pine (1993-1997); water resource baseline data and analysis of acid deposition impacts (1985, '87, '94); acid fog impacts to red spruce (1986-89), and mercury contamination in freshwater aquatic habitats (1995-1997). The air resource program at ANP is a collaborative effort involving the National Park Service Air Resources Division (ARD) and Northeast Regional Office, the Maine Department of Environmental Protection (MDEP), and park natural resource staff. In addition, there are a number of other important partnerships with the US Geological Survey, US Environmental Protection Agency, universities, and other state and regional agencies for conducting air related research and monitoring at ANP.

PROGRAM OBJECTIVES

The primary goal of the ANP air resource management program is to provide park managers with scientifically based information relating to the condition and well being of park resources including air quality related values. Specific objectives are to: 1) identify and establish baseline conditions for key air quality indicators; 2) determine air quality related changes and trends over time; 3) provide scientifically valid research and monitoring data to determine adverse impacts to park resources and air quality related values; and 4) provide the data and information necessary to make decisions regarding permits for new emission sources, and changes to state and federal air quality regulations. ANP air program staff and collaborators provide information on air resources to park employees, visitors, scientific and regulatory communities, the media, and other interested parties.

AIR MONITORING PROGRAM

A. Gaseous Pollutant Monitoring

1. Ground Level Ozone (O_3), (1982 – present). Ozone is a highly reactive form of oxygen and a major component of photochemical smog. Ozone is not emitted directly into the atmosphere but forms, as a secondary pollutant, as a result of chemical reactions that take place in the presence of heat and sunlight. Ozone precursors are nitrogen oxides and volatile organic compounds (VOC's). Ground level ozone has been monitored at ANP since 1982 at McFarland Hill, and since 1995 at Cadillac Mountain. The MDEP has responsibility for routine day-to-day operation of gaseous pollutant monitoring at the two ANP sites.

The US Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for several air pollutants including ozone. Prior to 1997, the federal ozone standard was a one hour average of 0.120 parts per million (ppm). States, however, have the option of establishing stricter standards, and Maine's ozone standard prior to 1997 was 0.081 ppm. In 1983, '84, '87, '88, '89, '91, and '95 ozone at ANP exceeded the federal one hour standard. The Maine standard was exceeded on 33 days, and a total of 218 hours in 1988, the worst ozone year on record. The highest recorded ozone concentration at ANP was 0.179 ppm in June 1988. During the same ozone event a 0.202 ppm, was recorded at a MDEP monitor on Isle au Haut, adjacent to ANP boundary. MDEP officially reports ozone and other gaseous pollutant monitoring data for ANP to the national EPA database. Table 1. provides a summary of ANP ozone monitoring data.

In 1997, the EPA established a new NAAQS for ozone of 0.080 ppm averaged over 8 hours, which Maine also adopted. Based on EPA's rounding convention the new standard is exceeded at 0.085 ppm (or 85 parts per billion [ppb]). From May through September, ozone concentrations at ANP periodically reach 85 ppb or greater, as do most other areas along the Maine coast. ANP exceeded the 8-hour standard a total of 5 days in 1997, and 8 days in 1998. In addition to the human health concerns posed by high ozone levels, recent research indicates that some species of vegetation are sensitive to ambient ozone levels (see Research section).

Maximum daily ozone levels at ANP most often occur between 6pm and midnight, reflecting the long-range transport by prevailing winds of polluted air masses from urban and industrial areas to the south and west. Most periods of unhealthful ozone at ANP only last a few hours. Prolonged periods of unhealthful ozone occur when a high-pressure system becomes stationary causing polluted southwesterly winds to stall over the area. The park has developed an **Ozone Advisory Program** to notify visitors and employees when ozone reaches unhealthful levels.

Although ANP periodically experiences maximum ozone concentrations that are among the highest in the eastern US, average daily levels during the ozone season are usually 35–40 ppb, well within the good range on the ozone health index. The same holds true when comparing ANP to other National Parks, where maximum ozone concentrations at ANP are among the highest of any park (Fig.1). However, average concentrations, and season long cumulative doses above the 60 ppb (SUM60) concentration level often associated with vegetation injury, are significantly lower than other parks such as Shenandoah, Great Smoky Mountains, and Sequoia (Fig.1a)

It is important to distinguish between ground level (Troposphere) and upper atmosphere (Stratosphere) ozone. Stratospheric ozone is beneficial in protecting the earth from the harmful effects of solar radiation, and is destroyed by chlorofluoro-carbons (CFC's) from a variety of man-made products including aerosol sprays, solvents, foam packaging, insulating materials and refrigerants (see sections on UV-B monitoring and research).

2. Sulfur Dioxide (SO_2) (1988-1991), is a highly reactive gas, which is soluble in water forming sulfurous and sulfuric acid, and can be converted in the atmosphere into the particulate sulfate. These various sulfur compounds contribute significantly to acid rain and visibility reduction, both of which are of concern at ANP.

Sulfur dioxide was monitored continuously at ANP from 1988-1991. The objectives were to establish an SO_2 baseline for the park, and determine whether or not ambient concentrations were at problem levels. ANP discontinued continuous monitoring due to consistently low ambient levels, less than 0.02 ppm. The EPA standard for sulfur dioxide is a 24-hour standard of 0.14 ppm. Sulfur dioxide is currently monitored bi-weekly as part of the IMPROVE fine particulate monitoring program.

3. Nitrogen Oxides (NOx) and Volatile Organic Compounds (VOC), (1995 – present), are precursors to ozone formation and contribute to other air pollution problems. Nitrogen dioxide (NO_2), one of the oxides of nitrogen, is a reddish brown gas which contributes much of the color associated with smog. NOx compounds also convert to nitric acid, a major component of acid rain, and to nitrate a particulate which contributes to both acid rain and visibility reduction.

In 1995, MDEP (with EPA support) established a Photochemical Assessment Monitoring Site (PAMS) on Cadillac Mountain at ANP. The PAMS site includes continuous monitoring for NOx,VOC's, ozone, and meteorological parameters. The EPA standard for nitrogen dioxide (NO_2) is an annual arithmetic mean not to exceed 0.05 ppm. Nitrogen dioxide levels at ANP have remained well below the federal standard.

B. Meteorological Monitoring

A number of key meteorological parameters are monitored at both the McFarland Hill and Cadillac Mountain sites, including wind speed and direction, relative humidity, temperature, solar radiation, and rainfall. In addition to providing data essential to assessing the basic ecological integrity of park ecosystems, meteorological data are also used in various modeling applications (e.g. back trajectory analysis) to determine potential air pollution sources and source areas.

C. Visibility Monitoring

Views from Cadillac Mountain and other park summits are intregal to the visitor experience at ANP. The Clean Air Act established the goal of remedying any existing and preventing future manmade visibility impairment in the nations National Parks (P.L. 95-95). Visibility impairment is usually characterized as either plume blight (visible emissions from a stack) or regional haze. At ANP, and most other parks in the east, regional haze is the primary source of visibility impairment. It is generally believed that there has been at least a 50 percent reduction in visibility in the eastern United States since the 1940's. This reduction in visibility not only affects how far one can see from a scenic viewpoint, but also how clear the view appears. Air pollution dulls color and obscures landscape features. The primary objectives of visibility monitoring are: 1) establish baseline data and track trends, 2) determine the relationship between visibility impairment and various atmospheric constituents, 3) determine sources of particles producing visibility impairment, and 4) determine the sensitivity of various sites to varying concentrations of particles. There are 3 major components to the visibility monitoring program:

1. Fine Particulate Monitoring, as part of the **I**nteragency **M**onitoring of **Pro**tected **V**isual **E**nvironments (**IMPROVE**) program (1987-present). This program involves weekly sampling of fine particulates in the 0-2.5 (PM2.5), and 0-10 (PM10) micron size ranges, and analyzes for mass volume, elemental compounds (H, Na-Pb), nitrate, sulfate, organic and elemental carbon. PM2.5 is the size range that is most effective in scattering and absorbing light in the wave length perceived by the human eye, thus affecting the color and contrast of the visual scene.

IMPROVE analyses can be used to differentiate between biogenic and anthropogenic pollution sources, and when combined with meteorological data and modeling, determine emission source locations. Sulfate is the largest contributor to visibility impairment at ANP accounting for approximately 62 per cent of aerosol light extinction, followed by organic carbon (18%), nitrate (8%), light absorbing carbon (7%), and coarse particles and fine soil (5%).

2. Optical monitoring, Optical measurements of ambient air have been taken at ANP since 1980 using a number of different instruments. Data can be analyzed to determine the extinction coefficient of ambient air (i.e. point at which light cannot be seen due to fog, clouds, smoke, or air pollution); or standard visual range (distance one can see an object through the atmosphere). Since 1993, an integrating nephelometer has been used to measure the light scattering component of extinction. In general, visibility conditions at ANP are best during the fall, and poorest during the summer.

Based on **IMPROVE** data from 1988–1996, visibility on good (best 10%) to average days at ANP has improved slightly, but there has been no change in days with poor (worst 10%) visibility (see Fig. 2.).

3. Scene monitoring, (1980-1995)**.** Long-term camera monitoring has been used to qualitatively characterize ambient visibility conditions of a specific vista. From 1980 to 1995 a 35mm camera was used to document the view toward Blue Hill, Maine from Cadillac Mountain. The camera took exposures three times daily (at 9am, 12 noon, 3pm) year around. A representative slide set showing the range of visibility conditions from Cadillac Mountain are available at the park. The complete slide database is archived at the ARD.

D. Atmospheric Deposition Monitoring

1. Acid Precipitation Monitoring - Acadia NP is one of more than 200 sites nationwide that participates in the **N**ational **A**tmospheric **D**eposition **P**rogram (**NADP**). The NADP, which began in 1978, is a long-term program to determine the chemical composition of atmospheric precipitation (rain and snow), and the spatial and temporal trends of deposition. The ANP site is one of four NADP sites in Maine. Operation of the ANP site is a cooperative effort between the park and MDEP.

Since 1982, acidity levels at ANP, as measured on the pH scale, have averaged approximately 4.5, with a range of 3.2 (very acidic) to 7 or higher (fig.3.). The pH scale is a logarithmic scale; one unit represents a ten-fold change, two units's a hundred-fold change and so on. In addition to measuring the acidity of precipitation, the NADP analytical laboratory also analyzes samples for a number of other chemical variables including major anions and cations, and sulfate and nitrate deposition. Since 1990, there has been a significant reduction in sulfate deposition while nitrate deposition has remained relatively unchanged (fig.4.). Reduced sulfate deposition is largely attributed to reduction in sulfur dioxide emissions required by the Clean Air Act Amendments of 1990. See table 2. For a summary of ANP acidic deposition data.

Fog, which is not measured by the NADP, tends to be more acidic than snow or rainfall and may be a major source of acidity to park vegetation.

3. Mercury Deposition monitoring – Mercury, a trace metal, is known to effect human health, fish and other wildlife predators including loons and eagles. In 1994, Maine issued a statewide fish consumption advisory warning of the high levels of mercury in some species of freshwater fish. To better understand the ecological impacts of mercury contamination on aquatic resources at ANP, a research study was initiated in 1995, with support from MDEP and the USGS Biological Resources Division (see research section). This study also led to continuous mercury wet deposition monitoring at ANP as part of the national Mercury Deposition Network (MDN).

3. Dry Deposition Monitoring – Because wet deposition is only part of total deposition, dry deposition (suspended particles that settle onto plant and soil surfaces) monitoring as part of the **N**ational **D**ry **D**eposition **N**etwork (NDDN) was initiated in 1998. Essentially the same set of parameters measured in the NADP program is monitored in the NDDN program. Preliminary studies suggest dry deposition of some atmospheric constituents may exceed the amount of wet deposition.

E. Ultraviolet Radiation Monitoring (UV-B)

In 1998 monitoring for UV-B radiation was initiated as part of the PRIMENet program (see below). A Brewer spectrophotometer, an instrument designed to measure different wavelengths of light, is used with a focus on the 300-320 nm wavelength. The Brewer also measures total column ozone, which along with solar irradiance is used to calculate UV intensity. The influence of sun angle, clouds and other forms of air pollution causes large seasonal variation in UV-B measurements, and it will likely take many years of monitoring to detect trends in UV-B levels.

RESEARCH

1. Atmospheric Deposition - Research and monitoring at ANP since the mid -1980's has found that most park surface waters (lakes and streams), on average, are non-acidic. However, short-term episodic acidification of many lakes and streams does occur, especially during spring snowmelt and runoff. In addition, alkalinity values at ANP, which are related to the ability of water to neutralize or 'buffer' acidic inputs, are among the lowest in the region. Recent research indicates alkalinity in some waters continues to decrease despite recent reductions in sulfate deposition. Additional research is being conducted at ANP to better understand episodic acidification impacts, watershed processes affecting deposition chemistry, and the spatial patterns of deposition associated with topography and other landscape features (see PRIMENet section).

2. Effects of ozone on native vegetation - a comprehensive study was conducted to determine the relative sensitivity of a variety of plants native to ANP to varying levels of ozone. From 1990 through 1993 more than 30 species of plants native to the park were exposed to ozone in controlled exposure experiments at a research site in the park. Open-top fumigation chambers were used to expose potted seedlings to 4 ozone treatment levels: 1) ambient ozone, 2) ambient + 50% ozone added, 3) ambient +100% ozone added, and 4) charcoal filtered air (ambient reduced approx. 50%). A fifth group included the same plants grown in a fenced enclosure (i.e. exposed to ambient ozone levels) which allowed for an assessment of chamber effects. Each treatment was replicated three times. Assessments were made for visible foliar injury as well as measurements on selected plants to detect changes in photosynthetic rate.

Species injured at ambient concentrations include: broad-leaf aster (*Aster macrophyllus*), black cherry (*Prunus serotina*), quaking aspen (*Populus tremuloides*) Jack pine (*Pinus banksiana*) White ash (*Fraxinus americana*) Spreading dogbane (*Apocynum androsaemifolium*). Species injured at concentrations 50% greater than ambient: Gray birch (*Betula populifolia*), Small sundrops (*Oenothera perennis*), Bunchberry (*Cornus canadensis*). Species not injured at any of the experimental concentrations of ozone include: White pine (*Pinus strobus*), Pitch pine (*Pinus rigida*), Red spruce (*Picea rubens*), Northern white cedar (*Thuya occidentalis*), Northern red oak (*Quercus rubra*), Canada blue-joint grass (*Calamagrostis canadensis*), Wild radish (*Raphanus raphanistrum*), Staghorn sumac (*Rhus Typhina*), Wild sarsaparilla (*Aralia nudicaulis*), Canada mayflower (*Maianthemum canadense*).

3. Field surveys for ozone injury - random and non-random populations of sensitive species (determined by fumigation exposures) growing naturally in the park were surveyed in August (1992-97) to determine the existence and extent of ozone injury. The surveys focused primarily on broad-leaf aster and spreading dogbane, but also looked at white ash, black cherry, and small sundrops. Each year 1200-2500 plants were examined. No symptoms of visible injury were found during 1992-94. In 1995 and '96 visible injury was observed on less than 10 percent of dogbane and aster plants examined. This low incidence of injury is consistent with low ozone levels recorded in the park during these years.

4. Ozone growth impacts - although there were no visible injury symptoms to white pine that could be attributed to ozone in the fumigation exposures, a companion study did find a significant correlation between radial (tree-ring) growth and ozone. This study assessed tree-ring width, climatological variables (precipitation and temperature) and ozone levels for a ten-year period and found radial growth inversely related to ozone level in seven out of eight white pine stands.

5. White pine needle blight pathology - Field and experimental chamber studies on eastern white pine have found that foliar symptoms formerly attributed to ozone are now thought to be associated with several insects and fungal diseases. Additional inoculation and fumigation studies are currently underway to investigate the relative roles of one particular fungus and ozone on producing foliar necrosis in white pines.

6. Mercury Contamination in Aquatic Environments - this ongoing research is evaluating mercury concentrations in fish and other biota from lakes and streams in Acadia NP, along with broader ecosystem implications. In some warm water fish species (bass, perch, pickerel) from selected lakes sampled, mercury concentrations were above US EPA human health standard of 1 part per million. Concentrations in cold water species (trout, salmon) in lakes sampled were generally within acceptable human health limits, except for those at highest risk e.g. nursing mothers and children. Additional research is investigating atmospheric deposition of mercury in sediment cores, and mercury concentrations in other fauna including loons, mergansers, tree swallows, and turtles.

7. UV-B Radiation - In recent years there has been growing concern with thinning of the stratospheric ozone layer (good ozone) which shields the earth from ultraviolet radiation. A number of chemicals such as freon and CFC's have been linked to chemical reactions that destroy protective ozone molecules in the stratosphere. Effects associated with UV-B radiation include increased incidence of skin cancer and cataracts in humans, damage to DNA and photosynthesis in plants, damage to phytoplankton and growth reductions in fish and crustaceans, and possible effects to other aquatic organisms such as amphibians and benthic macroinvertebrates. Research is planned to measure UV-B dose levels and other key chemical parameters in a variety of park waters, and correlate with amphibian population levels.

8. Other studies have investigated acid deposition and ozone impacts to red spruce, ozone impacts to aspen, and an air related characterization of the lichen flora of the park.

PRIMENet PROGRAM

The **P**ark **R**esearch and **I**ntensive **M**onitoring of **E**cosystems **Net**work (PRIMENet) is a cooperative USEPA/NPS long-term research and monitoring program designed to assess the effects of environmental stressors on ecological resources. Acadia is one of 14 National Parks nationwide that have been established as regional index sites to monitor environmental stressors and related ecosystem response. In addition to the core air and water monitoring programs, ultraviolet radiation (UV-B) monitoring using a Brewer Spectrophotometer was initiated in 1998. Initial research is planned to assess the potential impacts of UV-B to amphibian populations. Other research is being conducted to better assess the ecological effects of atmospheric deposition of nitrogen and mercury at both the watershed and landscape scales. Two hydrologically gauged-watersheds with differing ecological characteristics (one burned by a major fire, and another unburned) will be studied to compare patterns and processes in nitrogen and mercury retention and mobility. Input measurements of direct deposition and canopy throughfall will be compared to output concentrations (stream discharge) to determine nitrogen retention levels in soils, locations and processes of mercury speciation, and estimate nitrogen loading to adjacent estuaries. Current and historical vegetative histories, soil characterizations, and forest health assessments are being made for both watersheds.

Another study is evaluating the spatial (landscape and topography) patterns of atmospheric deposition to determine potential 'hotspots' of deposition. This study is designed to provide data necessary to develop a modeling capability that will allow point measurements of atmospheric deposition to be scaled to whole landscapes. Three hundred deposition collectors will be arrayed over varied terrain throughout the park, and a GIS-based approach will be used to develop the model.

PREVENTION OF SIGNIFICANT DETERIORATION ISSUES (PSD)

Acadia NP is one of 48 NPS units designated as a Class I area under the Clean Air Act, the highest level of protection under the act. Any new major emission source (or major modification of an existing facility), such as a power plant, must prove that the proposed facility will not exceed the Class I increment levels of the CAA, or adversely effect air quality related values in any Class I area. The ARD, with assistance from park staff, conducts a thorough review of all permit applications with the potential to affect park resources and provides technical comments and recommendations regarding potential impacts. These comments are forwarded to the appropriate state regulatory agency. The state has the authority to grant or deny the permit, or require mitigation such as emission offsets or use of best available control technology to reduce emissions. Research and monitoring data provide the information needed to document adverse impact and existing impairment, and to help determine appropriate regulatory action.

PARTNERSHIPS

The National Park Service has a formal Cooperative Agreement with **Maine DEP** for operation of gaseous pollutant monitoring at Acadia National Park. Maine DEP has primary responsibility for operation of the two monitoring sites at McFarland Hill and Cadillac Mountain (a Photochemical Assessment Monitoring Site). Also, National Park Service staff from Acadia National Park, the Northeast Regional Office, and the Air Resources Division participate in the Northeast Regional Air Quality Committee (NERAQC). **NERAQC** is a group of federal, state, and Canadian provincial and park air resource managers, with concerns about air quality in protected areas (including US Class I areas and Canadian National Parks) in the Atlantic provinces and the Northeastern United States. A formal Memorandum of Understanding has been adopted by NERAQC member agencies. The park also collaborates with **NESCAUM** (Northeast States For Coordinated Air Use Management) on a number of projects including a regional mercury study, and development of a real-time visibility camera network showing live pictures and related air monitoring data on an internet website.

EDUCATION AND OUTREACH

The Division's of Interpretation and Resource Management at ANP work cooperatively to communicate information on air quality to park visitors and other interested parties. Air related interpretive media include a display on the parks' air program in the ANP Nature Center, a roadside exhibit on visibility at the Blue Hill overlook on Cadillac Mountain, and an interpretive brochure entitled 'Air Currents' that is made available to visitors and groups interested in park air issues. Information on air quality is also included in many interpretive programs, poster displays, and in the park newspaper. Park staff have also developed close ties with local news media, and information on ANP air related research and monitoring are frequently incorporated into feature articles. In addition, Resource Acadia, an annual program of full-day comprehensive seminars on a variety of resource stewardship issues, including air quality, are presented to local residents and teachers. Additional information on the ANP air resource program, with links to a number of other sources of air quality information is available on the ANP internet homepage.

Table 1. Acadia NP Ozone Data Summary

McFarland Hill Site, 1983-1998.

	MAXIMUM 1 HOUR OZONE CONCENTRATION (PARTS PER BILLION)				# STATE Violations (1 hour>81ppb)	# 8-HOUR Violations
Year	High hour	2nd High	3rd High	4th High		
1983	138	135	130	128	97	11
1984	140	130	117	117	84	7
1985	120	117	102	101	60	3
1986	109	108	104	104	37	3

1987	130	126	121	118	40	6
1988	179	153	151	144	218	17
1989	130	114	105	104	23	2
1990	123	118	112	108	44	4
1991	128	125	125	122	78	7
1992	108	105	101	101	31	1
1993	112	104	93	93	38	3
1994	102	95	93	92	10	0
1995	128	127	119	115	66	5
1996	102	100	92	83	16	2
1997	117	98	97	93	16	1
1998	135	125	118	112	N/A	4

Cadillac Mountain Site, 1995-98

	MAXIMUM 1 HOUR OZONE CONCENTRATION (PARTS PER BILLION)				# STATE Violations (1 hour>81ppb)	# 8-HOUR Violations
Year	High hour	2nd High	3rd High	4th High		
1995	134	121	117	116	14	2
1996	100	96	94	93	52	1
1997	126	114	106	102	N/A	5
1998	132	123	118	100	N/A	8

Source: NPS Air Resource Division, Maine Dept. of Environmental Protection

Table 2. Acadia NP Atmospheric Deposition Data Summary 1982-1997

				DEPOSITION	
YEAR	MAX. PH	MIN. PH	MEAN PH	SULFATE (KG/HA)	NITRATE (KG/HA)
1982	6.14	3.58	4.49	22.7	11.1
1983	5.90	3.70	4.71	23.0	10.4
1984	5.40	3.20	4.59	22.0	11.0

1985	5.60	3.80	4.39	20.2	11.5
1986	5.30	3.80	4.49	23.7	12.2
1987	5.50	3.50	4.60	16.8	8.7
1988	5.80	3.40	4.56	19.5	10.0
1989	5.50	3.60	4.54	21.1	12.5
1990	5.20	3.70	4.51	22.7	14.6
1991	5.50	4.00	4.62	16.5	9.8
1992	7.50	3.78	4.50	18.1	12.4
1993	6.19	3.95	4.62	16.9	11.3
1994	5.28	3.90	4.66	15.9	9.1
1995	5.42	3.86	4.66	16.5	10.6
1996	5.83	4.03	4.64	15.0	10.7
1997	5.16	3.98	4.52	16.2	11.3

Source: National Atmospheric Deposition Program

Figure 1.

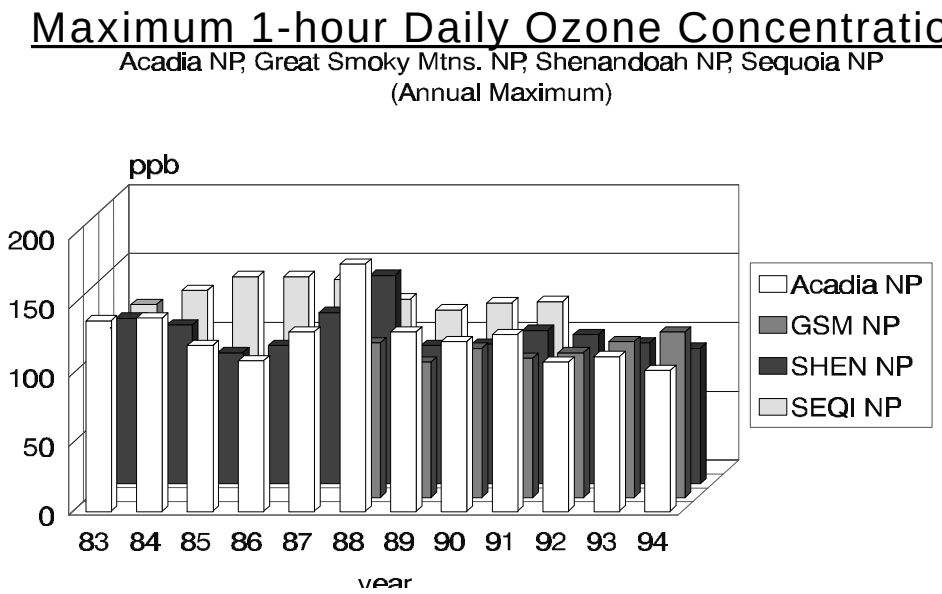
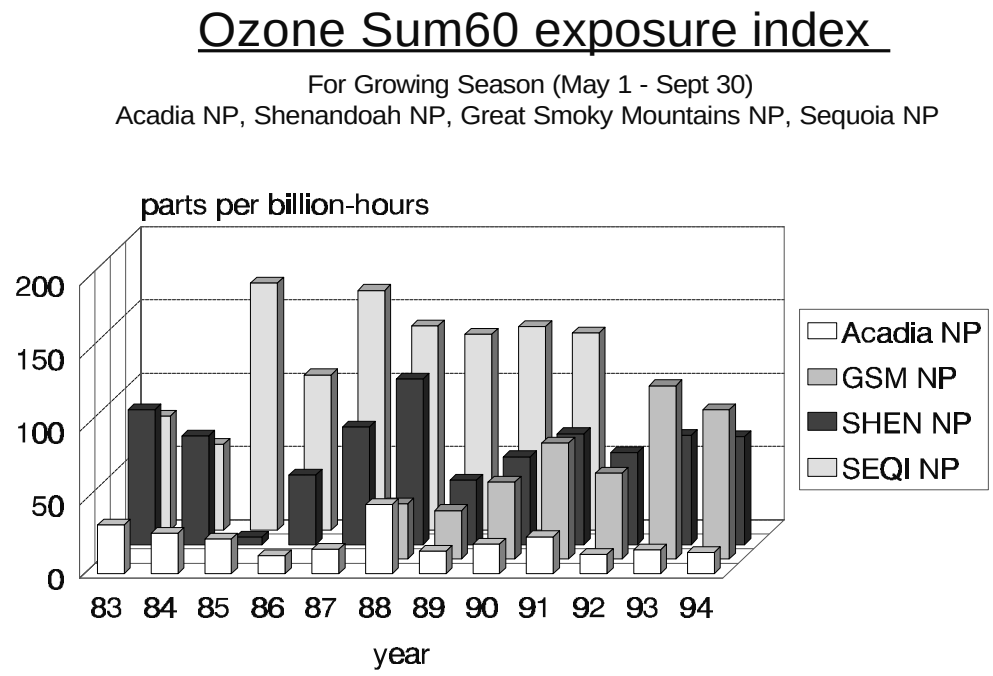


Figure 1a.



source: NPS Air Resources Division

Figure 2.

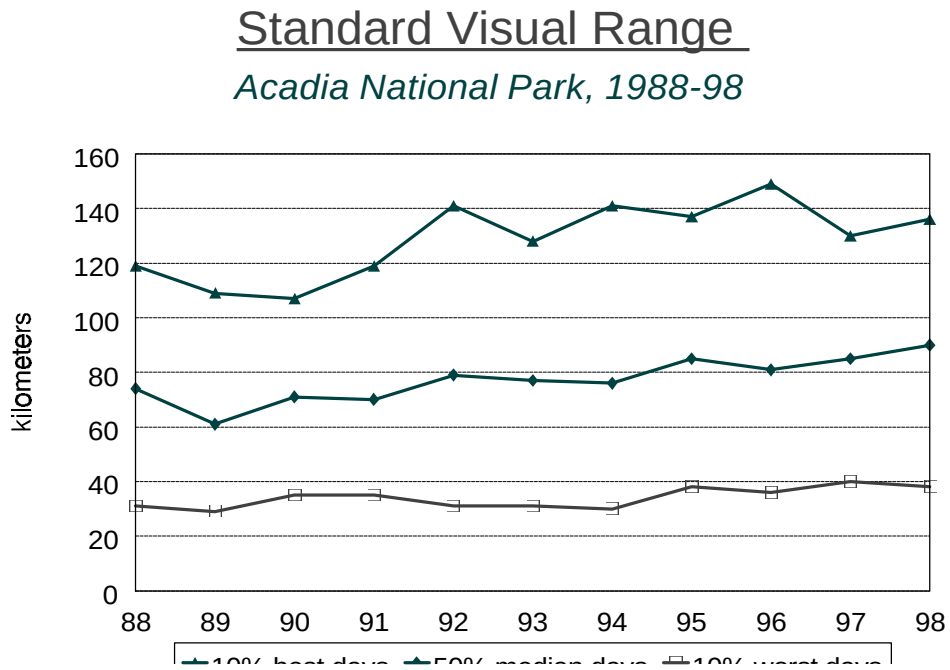
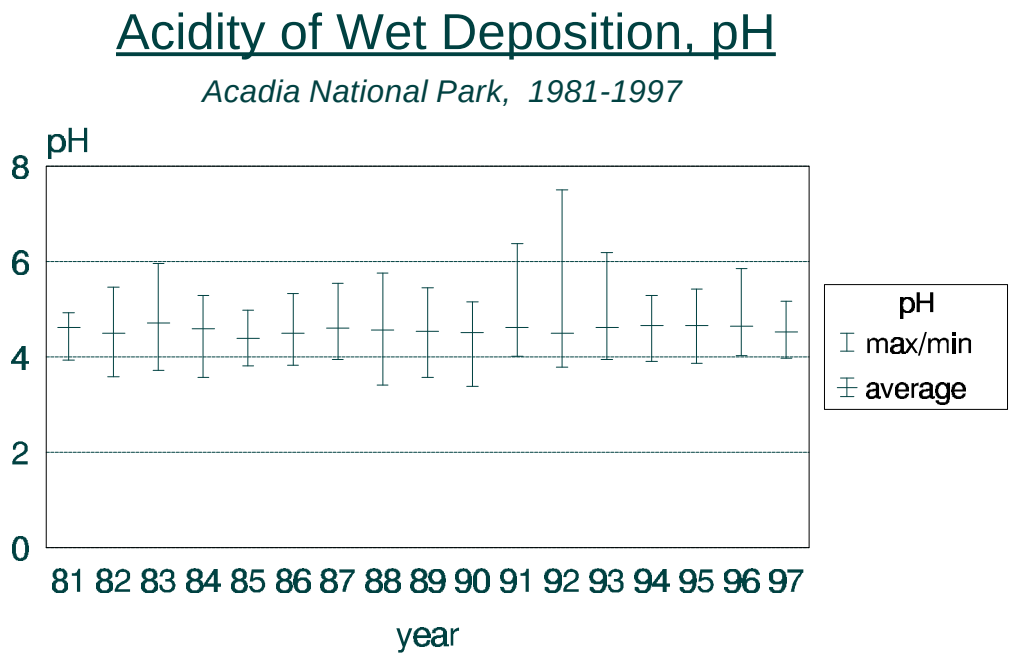


Figure 3.



source: National Atmospheric Deposition Program

Figure 4.